REMARKS

This application has been carefully reviewed in light of the Office Action dated January 3, 2002. Claims 1 to 6, 9 to 13, and 18 to 25 are in the application, of which Claims 1, 11, and 24 are independent claims. Reconsideration and further examination are respectfully requested.

Turning first to formal matters, the entire specification has been carefully reviewed and amended to improve its form.

Claims 1 to 25 were rejected under 35 U.S.C. § 112, second paragraph, for alleged indefiniteness. In response, the claims have been thoroughly reviewed and amended to improve clarity. Specifically, the term "particular pattern" has been removed. Withdrawal of the §112 rejection is respectfully requested.

Applicants thank the Examiner for his indication of allowable subject matter in Claims 8 to 12, 16, and 17. In keeping with this indication, Claim 1 has been amended with subject matter of Claim 8, and Claim 8 has been cancelled. Accordingly, Claims 1 to 6, 9, 10, 12, 13, and 18 to 23 are believed allowable.

Claims 1 to 6, 13 to 15, 18, 19, and 21 to 25 were rejected under 35 U.S.C. § 103(a)[1/] over U.S. Patent 5,789,734 (Torigoe) in view of Japanese patent JP-410284368A (Fukuda). Claim 20 was rejected under 35 U.S.C. § 103(a) over Torigoe in view of Fukuda and in further view of U.S. Patent 5,331,369 (Terasawa). Claim 1 has been amended, as indicated above, without prejudice and without conceding the correctness of the rejection. As for Claims 11 and 24, they have been amended to emphasize the feature of a common component, shared by first and second illumination systems, with separate illumination

1/ In entering this §103(a) rejection, the Office Action said that the claims were "anticipated". This would imply a rejection under §102, not §103(a), as otherwise mentioned in the Office Action. Since the rejection is clearly entered under §103(a) the word "anticipated" has been treated as an error. However, if a rejection under §102 was, in fact, intended, then clarification of this matter is respectfully requested.

conditions being defined interchangeably by adding a separate component to the common component or by removing the separate component. In view of these changes, withdrawal of the §103(a) rejection is respectfully requested, as detailed more fully below.

Claims 11 and 24 of the present invention relate to a projection exposure apparatus which includes a projection optical system, and a device manufacturing method using the same. A first illumination system projects a pattern of a first object under a first illumination condition onto a second object through an optical system. Further, a second illumination system performs illumination under a second illumination condition. The image of the pattern of the first object is illuminated by the second illumination system under the second illumination condition and a light intensity distribution of the image is detected. The wavefront aberration of the projection optical system is measured on the basis of the detection of the light intensity. The first and second illumination systems include a common component, and the first and second illumination conditions are defined exchangeably by adding a separate component to the common component or by removing the separate component.

The Torigoe patent discloses a projection exposure apparatus with a first illumination system (1) and a second illumination system (64 to 70). The second illumination system (64 to 70) has a structure where a portion of light is extracted from the first exposure illuminating system (1) and is directed through a series of optical elements (elements 64 to 70), through the projection optical system (31), and is reflected by a reference device (81) that reflects the projection back along its oncoming path to a spherical aberration detecting system (73). While Torigoe discloses an embodiment where the second illumination system (64 to 70) is illuminated by the first illumination system (1), the illumination systems are separate and distinct, and the illumination conditions are not defined exchangeably by adding or removing a component from some common component. Rather, Torigoe defines separate illumination systems that exist concurrently.

The structure is arranged to preform an exposure process while adjusting the spherical aberration to a moderate level.

Claims 11 and 24 of the present invention feature illuminating conditions that are defined exchangeably by adding or removing a separate component from a component common to both illuminating systems. Torigoe discloses a process where the exposure process and the spherical aberration determination can be preformed simultaneously. This is possible because the first and the second illuminating conditions are defined separately, as opposed to Claims 11 and 24.

Thus, the applied art is not seen to disclose or to suggest the claimed apparatus or method, and in particular is not seen to disclose or suggest at least the feature of first and second illumination systems which include a common component, and first and second illumination conditions defined exchangeably by adding a separate component to the common component or by removing said separate component.

No other matters being raised in the office action, it is believed that the entire application is fully in condition for allowance, and such action is courteously solicited.

Applicants' undersigned attorney may be reached in our Costa Mesa office by telephone at (714) 540-8700. All correspondence should continue to be directed to our address given below.

Respectfully submitted,



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APPENDIX

VERSION WITH MARKINGS TO SHOW CHANGES MADE TO CLAIMS

1. (Amended) A projection exposure apparatus, comprising:

a projection optical system for projecting a [transfer] pattern of a first object onto a second object;

a first illumination system for [performing illumination under a first illumination condition] illuminating the pattern of the first object under a first illumination condition, wherein the [transfer] pattern of the first object illuminated under the first illumination condition is projected onto the second object through said projection optical system;

a second illumination system for performing illumination under a second illumination condition;

a light intensity detector, wherein an image of the pattern of the first object, as the same is illuminated by said second illumination system and under the second illumination condition, is formed through said projection optical system, and wherein said light intensity detector detects a light intensity distribution of the image; and

an information processing system [operable, as a particular pattern being illuminated by said second illumination system under the second illumination condition is imaged by said projection optical system, to measure] for measuring a wavefront aberration of said projection optical system on the basis of the detection [of a light intensity distribution of an image of the particular pattern made through] by said light intensity detector[.];

wherein the first illumination condition concerns spatially partial coherency or incoherency, and wherein said second illumination condition concerns spatially coherency or approximate coherency.

2. (Amended) An apparatus according to Claim 1, wherein said information processing system is arranged to detect a phase distribution of the image of the [particular] pattern on the basis of light intensity distributions defined in relation to that image at different positions along an optical axis direction of said projection optical system, and to measure the wavefront aberration of said projection optical system on the basis of the detected phase distribution.

4. (Amended) An apparatus according to Claim 1, wherein said information processing system is arranged to measure the wavefront aberration of said projection optical system on the basis of light intensity distributions detected with respect to an imaging position of the image of the [particular] pattern and at least one defocus position of thereof, or of light intensity distributions with respect to different positions.

7. (Cancelled)

8. (Cancelled)

9. (Amended) An apparatus according to Claim [7] 1, wherein, in each of said first and second illumination systems, a ratio of a numerical aperture of said first or second illumination system to a numerical aperture of said projection optical system is σ, and wherein the first illumination condition satisfies a relation $0.2 < \sigma \leq 1.0$ while the second illumination condition satisfies a relation $\sigma \leq 0.2$.

10. (Amended) An apparatus according to Claim [7] 1, wherein said first and second illumination systems include a common element.

11. (Amended) A[n] projection exposure apparatus [according to Claim 10, further] comprising:

a [separate] projection optical system [which can be demountably added to said common element, to thereby interchange the first and second illumination conditions each other.] for projecting a pattern of a first object onto a second object;

a first illumination system for illuminating the pattern of the first object under a first illumination condition, wherein the pattern of the first object illuminated under the first illumination condition is projected onto the second object through said projection optical system;

a second illumination system for performing illumination under a second illumination condition;

a light intensity detector, wherein an image of the pattern of the first object, as the same is illuminated by said second illumination system and under the second illumination

condition, is formed through said projection optical system, and wherein said light intensity detector detects a light intensity distribution of the image; and

an information processing system for measuring a wavefront aberration of said projection optical system on the basis of the detection by said light intensity detector;

wherein said first and second illumination systems include a common component, and wherein the first and second illumination conditions are defined exchangeably by adding a separate component to said common component or by removing said separate component.

14. Cancelled.

15. Cancelled.

16. Cancelled.

17. Cancelled.

24. (Amended) A device manufacturing method, comprising the steps of:

performing a projection exposure [step] process for [projecting] exposing a wafer to a pattern of a reticle, [onto a wafer] by use of a projection exposure apparatus [including] which includes (i) a projection optical system for projecting a [transfer] pattern of [the reticle] a first object onto [the wafer] a second object, (ii) a first illumination system for [performing

illumination] illuminating the pattern of the first object under a first illumination condition, wherein the [transfer] pattern of the [reticle illuminated] first object illuminated under the first illumination condition is projected onto the [wafer] second object through [the] said projection optical system, (iii) a second illumination system for performing illumination under a second illumination condition, (iv) a light intensity detector, wherein an image of the pattern of the first object, as the same is illuminated by said second illumination system and under the second illumination condition, is formed through said projection optical system, and wherein said light intensity detector detects a light intensity distribution of the image, and (v) an information processing system [operable, as a particular pattern being illuminated by the] for measuring a wavefront aberration of said projection optical system on the basis of the detection by said light intensity detector, wherein said first and second illumination systems [under the] include a common component, and wherein the first and second illumination conditions [is imaged by the projection optical system, to measure a wavefront aberration of the projection optical system on the basis of detection of a light intensity distribution of an image of the particular pattern made through the light intensity detector] are defined exchangeably by adding a separate component to said common component or by adding a separate component to said common component or by removing said separate component; and

[a] developing [step for developing] the exposed wafer [processed by said projection exposure step, whereby a device can be produced from the developed wafer].

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In re Application of

YOSHINORI OHSAKI

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ORIGINALLY FILED

Docket No. 00684.003026

Application No.: 09/577,978

Examiner: H. Nguyen

Filed: May 25, 2000

Group Art Unit: 2851

For: PROJECTION EXPOSURE APPARATUS, AND DEVICE MANUFACTURING METHOD USING THE SAME

Date: July 3, 2002

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COMMISSIONER FOR PATENTS
Washington, D.C. 20231

Sir:

Transmitted herewith is an amendment in the above-identified application.

[X] No additional fee is required.

The fee has been calculated as shown below

CLAIMS AS AMENDED						
	(2) CLAIMS REMAINING AFTER AMENDMENT		(4) HIGHEST NO. PREVIOUSLY PAID FOR	(5) PRESENT EXTRA	RATE	ADDITIONAL FEE
TOTAL CLAIMS	19	MINUS	25	= - 0 -	x $9 $18	- 0 -
INDEP. CLAIMS	3	MINUS	3	= - 0 -	x $42 $84	- 0 -
Fee for Multiple Dependent claims $140°/$280						
			TOTAL ADDITIONAL FEE FOR THIS AMENDMENT---			- 0 -

* If the entry in Column 2 is less than the entry in Column 4, write "0" in Column 5.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, write "20" in this space.
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, write "3" in this space.

[] °Verified Statement claiming small entity status is enclosed, if not filed previously.

[] A check in the amount of $____ is enclosed.

☐ Charge $____ to Deposit Account No. 06-1205. A duplicate copy of this sheet is enclosed.

☒ Any prior general authorization to charge an issue fee under 37 C.F.R. 1.18 to Deposit Account No. 06-1205 is hereby revoked. The Commissioner is hereby authorized to charge any additional fees under 37 C.F.R. 1.16 and 1.17 which may be required during the entire pendency of this application, or to credit any overpayment, to Deposit Account No. 06-1205. A duplicate copy of this paper is enclosed.

☒ A check in the amount of $920.00 to cover the fee for a three month extension is enclosed.

☐ A check in the amount of $___ to cover the Information Disclosure Statement fee is enclosed.

☒ Applicants' undersigned attorney may be reached in our Costa Mesa office by telephone at (714) 540-8700. All correspondence should continue to be directed to our address given below.

Respectfully submitted,

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APPENDIX

VERSION WITH MARKINGS TO SHOW CHANGES MADE TO SPECIFICATION

Please replace the paragraph beginning at line 24 of page 2 with the following paragraph.

An example of measurement methods for wavefront aberration of a projection lens is a phase restoration method. This method has [bee] been used in the field of electron microscopes or astronomical telescopes having large aberrations, for improvement of the resolution. In accordance with this phase restoration method, a phase distribution of an image is detected on the basis of image intensity distributions at plural positions such as image plane, pupil plane, and defocus position, for example. From the detected phase distribution, a wavefront aberration of an optical system is calculated.

Please replace the paragraph beginning at line 3 of page 5 with the following paragraph.

For these reasons, when a wavefront aberration of a projection lens is to be detected in accordance with the phase restoration method while using an illumination optical

system for a practical exposure process [at] as it is, there is a problem [in] with respect to the precision.

Please replace the paragraph beginning at line 18 of page 14 with the following paragraph.

The phase restoration [method] method has [bee] been used in the field of electron microscopes or astronomical telescopes having large aberrations, for improvement of the resolution. In accordance with this phase restoration method, a phase distribution of an image is detected on the basis of image intensity distributions at plural positions such as image plane, pupil plane, and defocus position, for example. From the detected phase distribution, a wavefront aberration of an optical system (projection lens) is calculated.

Please replace the paragraph beginning at line 3 of page 17 with the following paragraph.

Generally, the value σ in regard to the illumination condition for wafer exposure to print a pattern on the wafer is in a range of about 0.3 to 0.8. Thus, the zoom optical system may be one covering such range. In the phase restoration method, on the other hand, a reticle must be illuminated in an approximately coherent state wherein σ is not greater than 0.2, preferably not greater than 0.1. For most convenient illumination with σ of 0.2 or less, the

aperture 22 shown in Figure 2 may be narrowed to satisfy $\sigma \leq 0.2$. In that occasion, since at the illumination state adjusting unit 20 the light has an expansion as of about $\sigma = 0.3$, an eclipse may occur at the stop 22 portion and, as a result, the light quantity may decrease. Particularly, the light quantity may reduce[s] if σ is not greater than 0.1. Thus, with the phase restoration method wherein the light intensity is to be measured, it may adversely influence the wavefront aberration calculation precision. While a zoom optical system that can cover a range of σ from 0.1 to 0.2 may be used, enlargement of the zoom ration causes an increase in size and weight of the illumination state adjusting unit 20. Further it becomes difficult to suppress non-uniformness of illuminance for all zoom lenses.

Please replace the paragraph beginning at line 1 of page 18 with the following paragraph.

In this embodiment, in consideration of the above, as shown in Figure 5, for execution of the projection lens on the basis of the phase restoration method, the illumination state adjusting unit inside the illumination optical system 13 is replaced by the illumination state adjusting unit 24 for the phase restoration method while, on the other hand, the stop is replaced by the stop 25 to change σ to be not greater than 0.2. More specifically, for the exposure process, a zoom optical system with which σ can change from about 0.3 to about 0.8 is used in the illumination state adjusting unit 20. For execution of the phase restoration method, the illumination state adjusting unit 24 for phase restoration method [which] which σ becomes not

greater than 0.2 is used. In this manner, in both of the exposure process and phase restoration process, the reticle can be illuminated with best modes, respectively. As a result of this, the wavefront of the projection lens 1 can be measured very precisely.

Please replace the paragraph beginning at line 27 of page 18 with the following paragraph.

In this embodiment, as shown in Figure 6, for[e] execution of wavefront aberration measurement based on the phase restoration method, a demountable mirror 27 being movable out of the light path is inserted between a stop 22 and a lens unit 23. A second light source 26 emits light of the same wavelength as the exposure wavelength, so that, through the mirror 27 and the lens 23, a pattern on a reticle 2 is illuminated in coherent state or approximately coherent state. This differs from the first embodiment of Figure 2.

Please replace the paragraph beginning at line 2 of page 20 with the following paragraph.

In this embodiment, as shown in Figure 7, a second optical system 14 is provided, in addition to the exposure illumination system 13. For detection of a wavefront aberration of the projection lens 1 on the basis of phase restoration method, the second optical system 14 is used to illuminate a pattern on the reticle 2. Also, for an exposure process, the second optical

system 14 as well as the mirror 15 move in a direction of an arrow in Figure 7 so as not to interfere with the exposure light. Namely, they are demountable out of the light path. Further, the illumination condition of the second illumination optical system 14 satisfies coherent illumination ($\sigma = 0$) or approximately coherent illumination ($\sigma \leq 0.2$). Thus, the wavefront aberration of the projection lens 1 can be measured, under an idealistic condition for the phase restoration method.

Please replace the paragraph beginning at line 1 of page 21 with the following paragraph.

Figure 8 is a schematic view of a main portion of a projection exposure apparatus according to a[n] fifth embodiment of the present invention. In Figure 8, elements corresponding to those of Figure 1 are denoted by like numerals.

Please replace the paragraph beginning at line 5 of page 22 with the following paragraph.

The phase restoration method using the above-described alignment optical system will now be explained. For the alignment measurement process, the alignment mark is illuminated usually with a condition of $0.2 \leq \sigma \leq 1.0$. To this end, in the alignment optical system shown in Figure 8, an interchangeable stop 32 is disposed between the illumination system relay

optical system 33 and the beam splitter 29, such that the σ value can be changed between the alignment process and for execution of wavefront aberration measurement based on the phase restoration method. More specifically, for execution of the wavefront aberration measurement based on phase restoration, the stop is changed to provide $\sigma \leq 0.2$, to illuminate a pattern on the reticle. The intensity distribution of an image thereof is then measured by [suing] using a light intensity measuring system 8, by which the wavefront aberration of the projection lens 1 can be calculated. Namely, as shown in Figure 8, the interchangeable stop 32 is provided inside the alignment optical system, so that the stop is interchanged between alignment measurement and wavefront measurement based on phase restoration, thereby to assure best illumination states for them. With this structure, without use of any additional optical system, the phase restoration method can be executed very precisely, and the wavefront aberration of the projection lens 1 can be calculated conveniently and very precisely.

Please replace the paragraph beginning at line 25 of page 30 with the following paragraph.

Figure [10] 11 is a flow chart of procedure for manufacture of microdevices such as semiconductor chips (e.g. ICs or LSIs), liquid crystal panels, CCDs, thin film magnetic heads or micro-machines, for example.

Please replace the paragraph beginning at line 21 of page 31 with the following paragraph.

Figure [11] 12 is a flow chart showing details of the wafer process.